HEC 12: Trail Blazers

Electrical & Mechanical Engineering

Automated Water Heating System

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Sponsor: Department of Mechanical Engineering of the University of Texas at Tyler.
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Background:

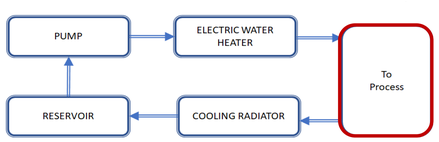
The current Heat exchangers testing system being used in the Mechanical Engineering Laboratory at the University of Texas At Tyler consists of DLMX (Desktop Learning Modules) which requires a manual addition of water heated in a coffee decanter on a hot plate. Failing to provide water at specific temperature while reducing experimental results accuracy.

Concept Statement:

Design and build an automated water heater system integrated to not only one but multiple heat exchangers capable of providing water at a specific temperature flowrate and pressure.

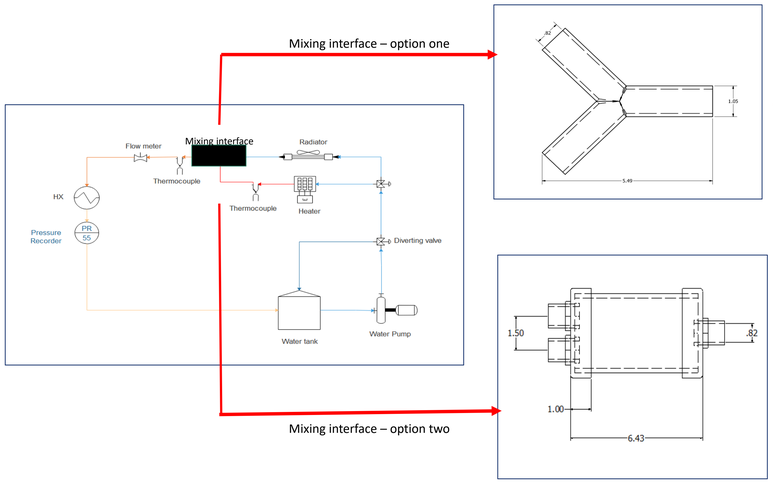
Flow chart:

This system is constituted of four main elements interconnects between each other in a closed loop.



Hydraulic Schematic:

- The Piping and instrumentation diagram shows the arrangement between mechanical and electronics parts.
- They are two mixing chamber options, a y-shape pipe and a custom-built mixing chamber, both constituted of two inlets for cold and hot water and one outlet for the mixed water.



Abstract:

The purpose of this project is to design and build an automated water heating system, that will be integrated to multiple heat exchangers. The project aims to replace the obsolete DLMX unit currently being used in the Mechanical engineering laboratory at the University of Texas at Tyler, and additionally increase the accuracy of the experimental results conducted by students. This applied project is sponsored by the Department of Mechanical Engineering of the University of Texas at Tyler. A team of three undergraduate students carried out this project as their senior engineering year design project.

Specification:

Client specification
- Water temperature 25°C to 60°C
- Flow Rate 1- 3 GPM
- Portable from one laboratory table to the other (4'X4')
- Power source 110V
- Closed system
- Fluid Type: Water (Refer to manufacturer for use of other liquids)
- Quick Connects: CPC 3/4"

Mechanical parts
- Heater (27 KW)
- Radiator (5 GPM HC)
- Diverting Valve (Percentage)
- Pump (7 GPM)
- Mixing Chamber (custom-built)

Electrical parts
- Temperature Sensor
- Flowrate Sensor
- Pressure Sensor

Key Equations :

Pressure drop in pipes

Bernoulli equation:

$$\frac{Pb}{\varphi \cdot g}+\frac{Vb^2}{2 \cdot g}+Zb=\frac{Pc}{\varphi \cdot g}+\frac{Vc^2}{2 \cdot g}+Zc+\frac{(f \cdot Lpipe \cdot Vpipe^2)}{Dpipe \cdot 2 \cdot g}+\frac{\left(\sum K \cdot Vpipe^2\right)}{2 \cdot g}$$

Thermal load (Demand) associated with the operation of the heater:

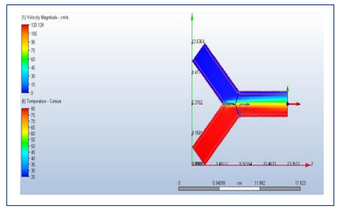
$$Q_m := GPM_{heater} \cdot \left(60 \cdot \frac{min}{hr}\right) \cdot \left(8.34 \cdot \frac{lb}{gal}\right) \cdot \left(\frac{Btu}{lb}\right) \cdot \left(\frac{1}{1 \cdot °F}\right) \cdot \Delta T_h = 809.317 \frac{J}{s}$$

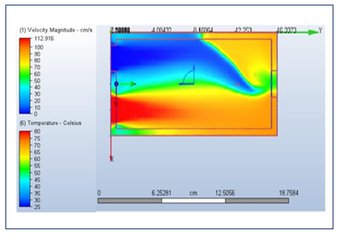
PUMP ANALYSIS

$$NSPHa = \frac{P_1}{\delta} + Z_a - \left(\sum f \cdot \frac{L_{pipe}}{D_{pipe}} \sum K + 1\right) \cdot \frac{V_{pipe}^2}{2 \cdot g} - \frac{Pv}{\delta} = \frac{P_2}{\delta} - \frac{Pc}{\delta}$$

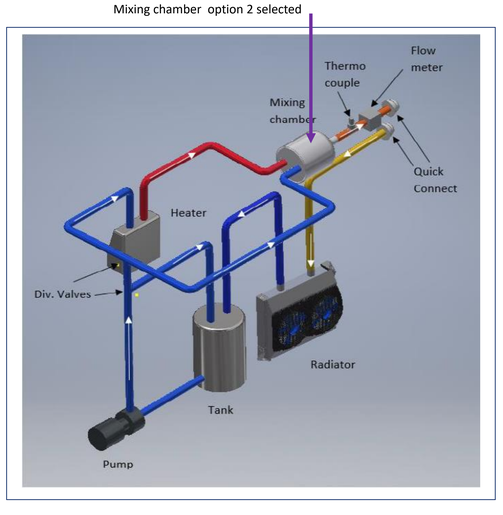
Key Decisions:

- The mixing chamber selection is made based upon ANSYS Computational Fluid Analysis,
- Water at the exit of the y-shape mixing chamber is less homogenous than the water at the exit of the custom-made mixing chamber. Therefore, the custom-built mixing chamber is favorable.



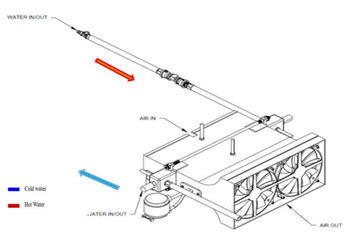


Mixing chamber option 2 selected



Future Integration:

- HEC 17's Cross-flow Heat Exchanger Radiator (cold water source) and HEC 12 heating system(hot water source) are both connected to heat exchanger.
- HEC 12's LabVIEW VI can be added to HEC'10 LabVIEW control, providing a general control user interface for all other heat exchangers testing groups.

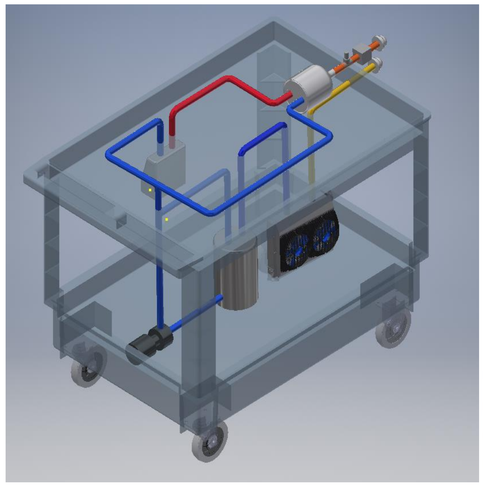


HEC 17-Cross Flow Heat Exchanger Radiator

HEC 10 LabVIEW Control Interface

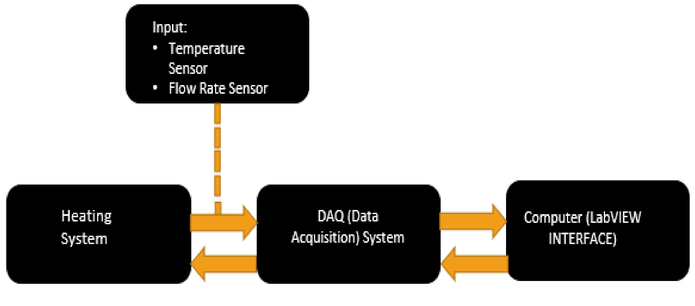
Final Assembly:

Final representation of all mechanical and electronics components inside a heavy-duty movable cart.



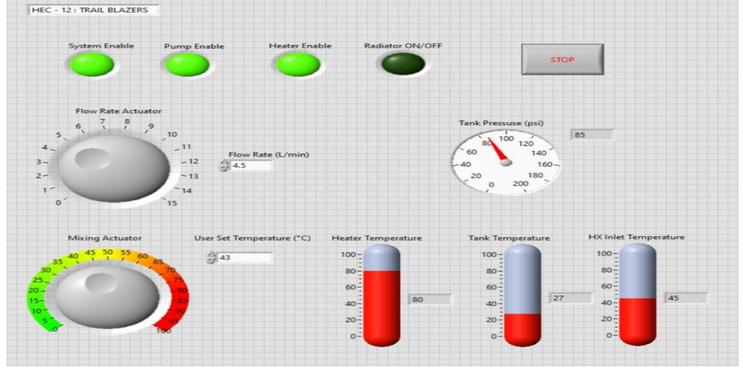
System Software Flowchart:

- The National Instrument's DAQ (Data Acquisition) system plays the role of a bridge between the water heating system and the user computer (LabView Interface)
- The DAQ converts analog waveforms from sensors into digital values for processing.



User LabView Interface:

On this interface, the users can input desired water temperature and flowrate that can then be achieved by the heating system.



Conclusions:

The HEC 12's Automated water heating system provides desired temperature and flowrate to one or multiple heat exchangers . It replaces the current water heating system that consists of coffee decanter and a hot plate. This automated water heating system not only improves in safety but in efficiency in comparison to the current water heating system. The collection of analysis and research provided by HEC 12, proves the effectiveness and efficiency of this advanced water heating system.

Future work :

- Finalize the physical assembly of all components of the system
- Finalize the building of all different electrical circuits of the system
- Explore possibility of providing water at multiple temperature to different heat exchangers.
- Strengthen the control system by combining LabView with other software such as MATLAB Simulink.
- System testing and analysis
- Effectuate detailed safety testing
- Finalize the user manual
- Sign off bill
- Delivery

Acknowledgements :

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